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Contained are a collection of science activities based upon forty-six scientific concepts related to space science. These activities are designed for junior high school science, but a much wider grade level range of use is possible. The booklet is primarily intended for teacher use. Each series of concept-oriented activities is independent of the others. The format consists of concept introduction, teacher information, and student activities. Application of the scientific concepts to aerospace technology are emphasized. (RR)

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ACTIVITIES IN SCIENCE RELATED TO SPACE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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ACTIVITIES IN SCIENCE RELATED TO SPACE

These equipment experiments are available to summer sessions of 1968 for the purpose of obtaining suggestions for revision prior to publication. Please send your suggestions and criticisms to Mr. Everett E. Collin, Educational Programs Division, FE, NASA, Washington, D.C. 20546.

EFFECTS OF A METEOR STRIKE

CONCEPT: The surface of the moon may be pitted as a result of meteoric impacts. These craters are much larger than the impinging meteors.

TEACHER INFORMATION:

The impact of a small sphere produces a much larger crater than the size of the sphere.

ACTIVITY I

Step 1.
Drop stones into a soft mud pie.

Step 2.
Try dropping the stones at various angles.

Step 3.
Increase the velocity.

Step 4.
Observe the effects.

ACTIVITY II

Make a model of the moon's surface using plaster of paris and different size "meteors."

TEACHER INFORMATION:

Research is now being conducted in an effort to perfect a buffer shield for satellites and manned spacecraft which will serve as a protection from meteoroid penetration. Vacuum chamber tests have shown that a spacecraft can be protected from meteors by a relatively thin layer of metal or other material about one inch or so from the surface of the craft. It has been found that most of the energy of motion possessed by a meteor is absorbed by the buffer shield.

ACTIVITY III

Repeat activities 1 and 2 and stretch a sheet of plastic or foil about 1" above the surface. Compare the crater sizes.

THE SIZE OF THE SUN

CONCEPT: The apparent size of objects is dependent on their real size and their distance from the observer.

TEACHER INFORMATION:

The question "If the sun is a star, why does it look so large when compared to the other stars?" can be answered by inference from the following activity--

ACTIVITY I Step 1 - Obtain a one-gallon and a one-half pint jar, both with the same general shape.

Step 2 - Before the class, place the gallon jar in view of your room, about two hundred feet from the school building.

Step 3 - During class time hold the 1/2 pint jar in front of the class and point out the jar outside. Ask the question of the children, which jar do you think is the larger of the two?

Step 4 - Have one of the pupils retrieve the gallon jar and then discuss the comparative sizes of the two jars.

ACTIVITY II Step 1 - Obtain a large beach ball or a basketball and a marble. Relate the sizes of the spheres to the sun and the moon.

Step 2 - Have a pupil A hold the marble between two fingers and at arm's length. Have a pupil B stand about 5' from pupil A and hold the large ball at eye level.

Step 3 - Pupil B should move to the proper distance from pupil A to have the marble just block off the large ball. This is an eclipse.

Step 4 - Have pupil A move the marble closer to and farther from his eye. Discuss the effect of this movement on the eclipse.

ACTIVITY III Ask for observations of the size of the sun and the size of stars. Discuss the statement: Our sun is just an average size star.

ACTIVITY IV Venus the planet is approximately the size of the Earth. We call Venus the morning or evening star dependent upon its time of visibility. Discuss.

TEACHER INFORMATION: An eclipse occurs when either the earth blocks the light of the sun from the moon or the moon block the light of the sun from the earth. The moon is about 2,000 miles in diameter while the diameter of the sun is about 865,000 miles.

SCHLIEREN PATTERNS

CONCEPT: The earth's atmosphere is not uniformly heated. Therefore, air movements occur which disturb astronomers" viewing and photographing of the heavens.

TEACHER INFORMATION:

A common experience of all is seeing a blurry or twinkling star. Also, because of these temperature variations, "good seeing" is only available for short periods of time at most observatories.

Demonstrate the effect of changes of temperature (and the resulting changes of density of the air) on light traveling through it, with the following:

ACTIVITY I Step 1 - Hold a test tube 1/2 filled with hot water in front of a bright light.

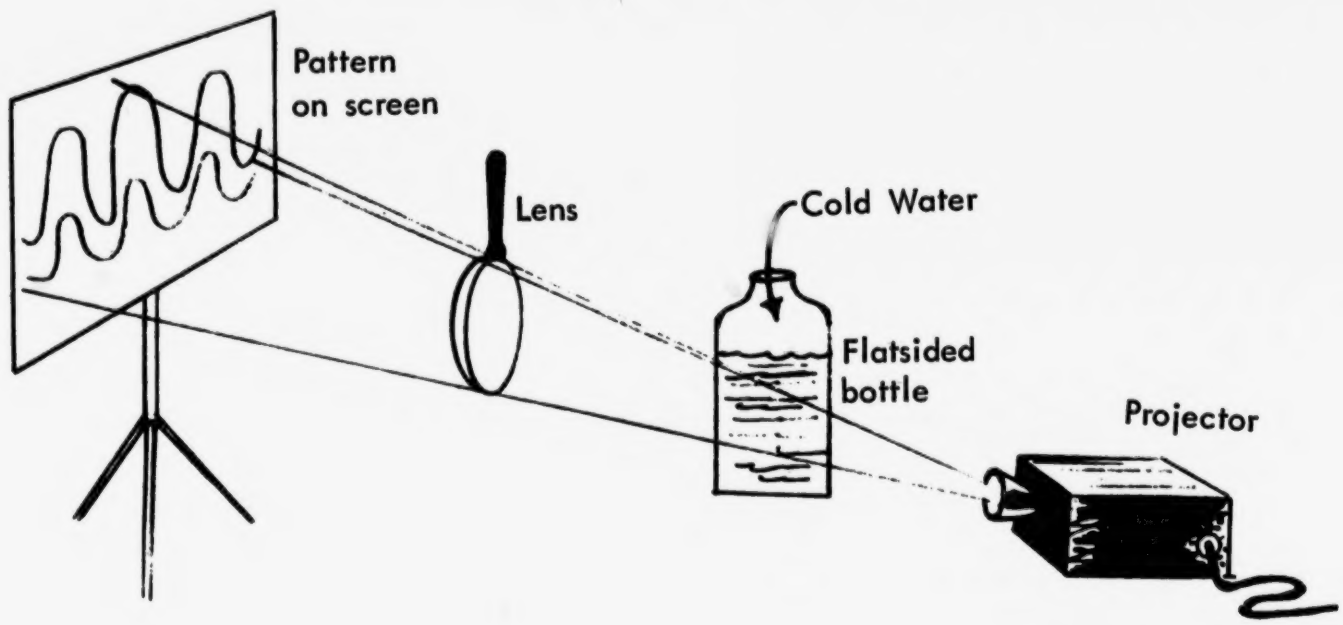
Step 2 - While looking through the tube, add some cold water. Note the turbulence lines called Schlieren patterns.

ACTIVITY II On a cold day, observe the turbulence over the top of a radiator in the classroom.

ACTIVITY III Step 1 - Use a flatsided bottle. Fill it half full of hot water.

Step 2 - Shine a projector's light through the bottle and focus on a screen with a large convex lens held between the bottle and screen.

Step 3 - Add cold water.



STAR COLOR AND COMPOSITION

CONCEPT: Stars have different colors.

TEACHER INFORMATION:

The color of stars depends upon the temperature and material of which the stars are made. Generally, red stars are cooler than ~~yellow~~ stars. Yellow stars are cooler than white stars, etc.

ACTIVITY I

Step 1.
Use a burner to heat a piece of ironwire. This wire can be obtained from the hardware store or 10¢ store as picture hanging wire.

Step 2.
Increase the temperature and note the change in colors. For good viewing, this is best done in a semi-darkened room.

CONCEPT: The composition of stars can be determined.

Wire pushed into cork for ease of holding

TEACHER INFORMATION:

When a material is heated to the point of radiating energy in the form of light, this energy is peculiar to that of material. The light we see emanating from burning coal is different from that of a burning match. However, this radiating energy is not always apparently different to our unaided eye.

Scientists have developed an instrument called a spectroscope which enables them to distinguish between the sometimes minute differences often evidenced in the colors of radiating matter. A spectroscope attached to a telescope enables a scientist to look at a star and determine what materials are radiating the light.

ACTIVITY II

Step 1.
Obtain the following materials:

a. a small replica grating (this may be called a diffraction grating in some of the catalogues of the scientific supply house). Make sure you do not spoil the grating by touching it with your fingers. Source: Edmund Scientific, Barrington, New Jersey, 25¢ each.

b. a shoe box, or a large candy box that has one long dimension

c. two single edged razor blades

d. an alcohol lamp, or a propane, or a candle

e. table salt, epsom salts, baking powder, sugar, a variety of salts obtained from your local drug store.

Step 2.
Cut a very thin vertical slit in the middle of one end of the box. In the other end of the box cut a hole just a tiny bit smaller than your piece of diffraction grating.

Step 3.
Tape the diffraction grating over the larger hole. Tape the two razor blades over the slit so that the edges of the blade may be squeezed together to form an extremely narrow and sharp slit.

Step 4.
Hold the grating to your eye and aim the slit toward an incandescent light. You should see a beautiful spectrum of colors on each side of the slit on the inside of the box. If your spectrum is above and below the slit, untape your grating and rotate it 90° and then re-tape it to the box. Look again. Now you're ready to look at the materials you assembled in "e" of step 1.

Step 5.
While you are looking in your spectroscope, have someone sprinkle a little of each of the chemicals in a flame from your heat source. Can you see the bright line fingerprints of each chemical. In most materials you will see a bright orange line. The line shows the presence of sodium which is abundantly present in the compound of table salt (sodium chloride).

Step 6.
From an encyclopedia or other available sources, gather some pictures of spectra of a variety of materials. Using your spectroscope, compare these spectra with those you see of the same materials. Remember that the spectroscope used in commercial and astronomical work is an extremely sensitive and expensive apparatus. This will account for many noticeable differences in the picture of spectra and the spectra you observe.

Step 7.
Encourage your pupils to use your spectroscope in examining many light "i e" burning fuels, flourescent lights, "neon" lights (many sign lights glow with a variety of colors because of the presence of a variety of gases in the tubes.)

ACTIVITY III

Read about the different star types and discuss how the astronomers know their contents.

ACTIVITY IV.

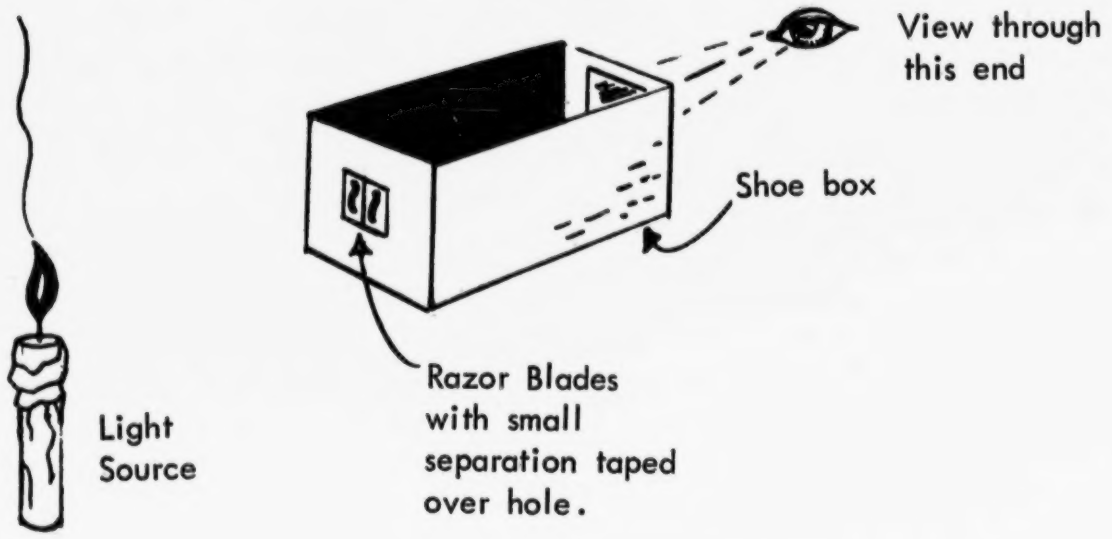
Step 1.
Obtain Fourth of July sparklers which burn with a variety of colors.

Step 2.
The pupils may classify these sparklers by identifying the colors with which they burn.

ACTIVITY V.

Step 1.
Obtain a variety of materials that are used to produce colors in a fireplace.

Step 2.
In your classroom, burn several pieces of this material and have your pupils observe the colors with which the material burns.



THE EARTH'S AXIS

CONCEPT: The earth is rotating on its axis.

TEACHER INFORMATION:

The result of the Earth rotating on its axis is often referred to as night and day. The circumference of the Earth at its equator is approximately 25,000. For a 24-hour day the rate of rotation, at the equator, must be a little more than 1,000 mph. At the 45th parallel the rate is about 500 mph; at the poles the rate is 0 mph.

Watching the apparent motion of the sun during the day will result in one's accepting the Earth-centered rather than the sun-centered solar system, because we can "see" the sun going around the Earth.

After discussion of the above facts the following activities will help your pupils understand the concept of the rotating earth.

ACTIVITY I

Step 1
Obtain a small heavy weight, a yard stick, a stand, and a piano stool. (Figure 1)

Step 2
Arrange the material as in the diagram.

Figure 1

Step 3
Swing the pendulum and observe the path the ball follows during several swings.

Step 4
While the ball is swinging, turn the piano stool slowing and observe the path of the swinging ball.

Now that you have observed that the pendulum continues to swing in the same plane, you have enough background information for Activity 2, called the Foucault pendulum.

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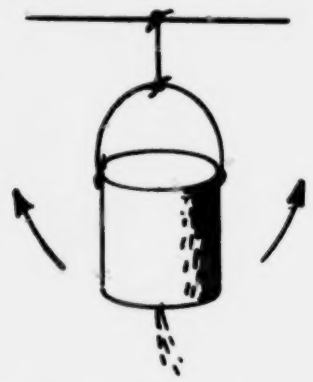
ACTIVITY II

Step 1
Fill a one gallon can with sand.

Step 2
Tie the sand filled can to a long length of 30 lb. test fish line and by means of a large fishing swivel fasten the line to the ceiling as in Figure 2 below. Have the can clear the floor by 3 or 4 inches.



Step 3
Pull back on the can and let it swing to make sure the area is clear enough.

Step 4
Tie the can 6 feet from perpendicular using light thread. While the can is tied back, punch a small hole in the bottom of the can so that the sand comes out very slowly.

Step 5
So that the can will swing in a plane, burn the thread holding it back.

Step 6
Observe the trail of sand grains over a period of several hours. Recall your results of Activity I for this concept of the rotating earth. Does the path of the pendulum change? If it does, repeat Activity I and observe closely.

Step 7
In the encyclopedia look up the Foucault Pendulum and report.

ACTIVITY III

Step 1
Obtain a camera that has a time exposure setting which will allow the shutter to be set open.

Step 2
On a clear night in an area with no artificial light, aim the camera at the north star and open the shutter. Leave the shutter open for 2 to 3 hours. Discuss the resulting picture.

MEASURING ALBEDO

CONCEPT: The planets and their moons reflect the sun's rays in various amounts.

TEACHER INFORMATION:

Albedo is a measure of reflectivity. The moon's albedo is 0.07 (moon reflects 7% of the sunlight it receives). The earth's albedo is 0.40 (reflects 40% of the sunlight). Albedos of the planets are:

Mercury	0.06	Saturn	0.50
Venus	0.7	Uranus	0.66
Mars	0.15	Neptune	0.62
Jupiter	0.51		

To measure albedo on earthly objects, a photographic light meter can be used. The scale on most meters read f/1.9, f/2.8, f/4, f/5.6, f/8, and f/16. Each larger number indicates a light intensity twice as great as the previous number.

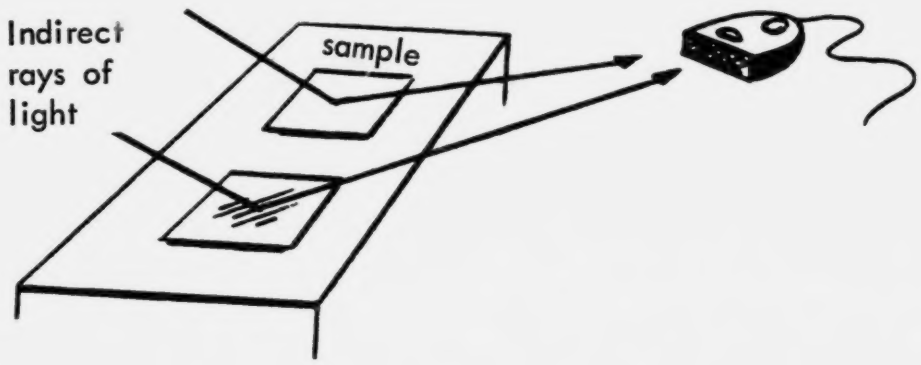
ACTIVITY I

Step 1
Place a gray sheet of paper near an open window out of direct sunlight.

Step 2
Pass the meter over the gray card and read the reading.

Step 3
Place a mirror on the table and measure the incident light coming through the window. This is your standard to compare with the reflected light on the various samples, such as the gray card.

Step 4
In the same way measure the reflected light of different colored paper, metals (such as sluminum foil), etc.



THE ALBEDO OF THE MOON

CONCEPT: The albedo of the moon varies greatly in different areas.

TEACHER INFORMATION:

The extreme brightness of the moon in the areas of the rays from some craters is unexplained. Many lunar geologists theorize that the material of these bright rays must be in the form of little glassy beads. An example of a material having extreme brightness from reflected light is a beaded projection screen.

To gain an understanding of the effect of the configuration of a material on its reflectivity, the following activities are suggested:

ACTIVITY 1

Step 1
In a darkened room, shine the light of a powerful flashlight on a mixture of fiber glass, clear glass, powdered glass (pulverized in a cloth bag), and window pane. Observe the difference in the amount of reflection.

Step 2
Observe a large, clear picture of the moon and theorize on the nature of the surface.

EARTH - MOON SYSTEM

CONCEPT: The Earth and Moon describe a complex system of motion as they move in their mutual orbit around the sun.

TEACHER INFORMATION:

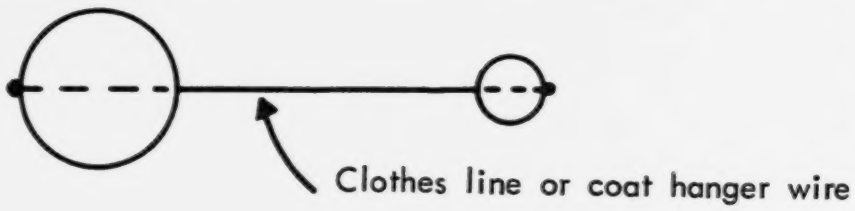
The moon is only about 1/80th as "heavy" as the earth, so they revolve around each other (not just the moon around the earth). This idea can be stimulated by the following activities:

ACTIVITY 1

Step 1
Prepare an Earth-Moon System using two rubber balls in approximate proportion to the size of moon and earth (1:4).

Step 2
Thread a cord through the balls and hold in place with knots. This cord (thin clothes line) should be about 2 feet long.

(Figure 1)



Step 3
Hurl the system through the air by grasping the small ball in one hand and swing your arm back and forth like a pendulum several times and then release the ball into the air as you would throw a softball underhand. With a little practice the balls will travel through the air while rotating about each other with the cord between them remaining taut.

Note: A coathanger wire may be substituted for the clothes line.

ACTIVITY II

Step 1
Attach ping pong ball to a large styrofoam ball with a 1 foot piece of heavy wire. (Figure 2)

Step 2
Support the system by a thread which is attached to the styrofoam ball so that the system is balanced.

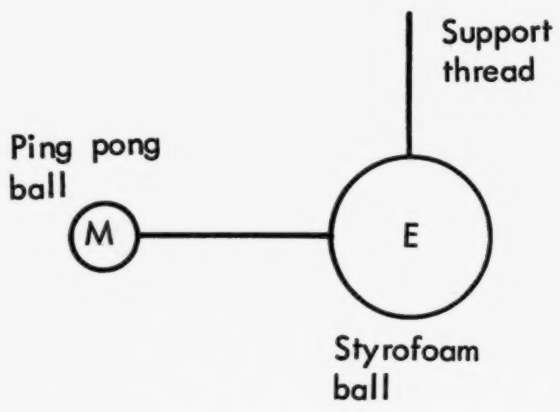
Step 3
Push the "moon" to start revolution.

ACTIVITY III

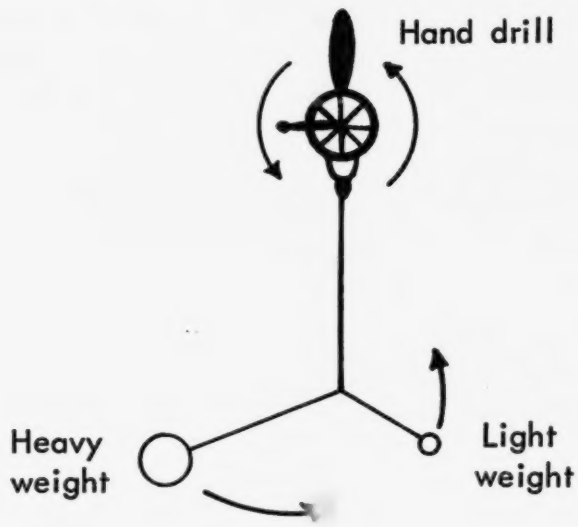
Step 1
Connect a heavy ball to a lighter one with a string -- have balls 6" apart.

Step 2
Attach another string to the chuck of a hand drill and the other end to the center of the string that is connecting the balls. (Figure 3)

Step 3
Turn the drill.



(Figure 2)



(Figure 3)

ACTIVITY IV

The balance point F of the Earth-Moon System, i.e., the center of gravity of the system, can easily be found algebraically if the system is considered as a lever. We know the mass of the earth to be approximately 81 times that of the moon. With this knowledge, the problem can set up as in Figure 4.

ACTIVITY V

At what distance would the centers of masses have to be if the CG is at the center of the earth with a given distance of 240,000 miles? Change the ratio of mass to cause CG at the center of the earth.

$81X = 240{,}000 - X \times 1$

$82X = 240{,}000$

$X = 3{,}000$ miles from center of earth

MEASUREMENTS - DISTANCE, TIME, WEIGHT

CONCEPT: Man has developed standards to measure time, distance, energy, motion, and matter.

TEACHER INFORMATION:

When communications between nations were poor, there were various standards of measurement. As the world grew smaller through mass increase in ability to travel and communicate, the necessity for the development of universal standards became evident. Consequently, standards of measurement were developed that have enabled man to expand his knowledge of the known universe. Without these standards, it would be exceedingly difficult, if not impossible, to communicate scientific knowledge.

Extremely large or small measurements of time, distance, energy, motion, or matter often require the establishment of varieties of standards. Examples of varieties of standards for the measurement of time are the second, minute, hour, day, week, month, year, decade, and century. Examples of the varieties of standards in the measurement of distance are inch, foot, yard, mile, millimeter, centimeter, meter, kilometer, astronomical unit, parsec and light year. These standards only show that a unit of measure is simply a man-construed device which makes communications more accurate and efficient.

Measuring Distance

LEARNING

Since space distances are enormous, the use of the unit MILE to measure distances in space would be quite cumbersome. Another unit of measure is needed.

ACTIVITY I

Assume that a jet plane goes about 650 miles per hour. Have the class calculate how long it would take the plane to reach Pluto (3,000 million miles away) or the nearest star (other than the sun) Alpha Centauri (26 million million miles away). For distant systems such as the nearest galaxy, Andromeda, and others, this jet yardstick is also too unwieldy. Try the speed of the Mercury spacecraft (18,000 miles per hour). Even this will be too small a unit.

LEARNING

Standards of measurement are arbitrarily established by man.

ACTIVITY II

An example of the development of a standard for the measurement of distance is: A potato could be selected as the standard of measure for one group. The longest dimension of the potato could be called one potato. An arbitrary distance marked off on the largest dimension of the potato could be called a po. A second arbitrary distance marked off on the potato could be called a ta. One po plus one ta could equal one potato. Discussion points for this activity could be:

a. What are the advantages of using a potato as a standard?
b. What are the disadvantages of using a potato as a standard?
c. How can we preserve the largest dimension of the selected potato or is this a problem?
d. How can we most effectively make sure that everyone knows what the standards of one potato mean?
e. What difficulties, if any, arise when the standard is used to make extremely large or small measurements?

ACTIVITY III

Divide the class into three or four groups and have each group establish its own standard for the measurement of time, distance, energy, motion, and matter. After each group has established its set of standards, ask each group to attempt to establish its set of standards as the one to be used for the entire class.

ACTIVITY IV

Instead of the steady ticking of a watch, the pulse beat of one of the students can be used to measure fairly short periods of time. Ten of these pulsations could represent a unit to replace the minute while one hundred beats of the pulse could represent a unit which replaces the hour.

For the measurement of long time spans such as the month, year or century, it will be necessary to use a new standard. Fill a large bottle with water or another liquid. Cap the bottle with a holed cover. Tip the bottle upside down and let the water drip out very slowly. Adjust the size of the hole in the cap and the size of the jar to approximate the period of time for which you desire a standard. Name the standard you develop.

Other standards of time that might be used: the length of time it takes a given candle to burn out; the length of time it takes a specially designed hour-glass type time to empty.

We measure some kinds of motion by saying "ten miles an hour" or "ten miles per hour." Using the standards of time and distance developed by your class, discuss and compare the speed of two or more moving bodies.

Don't forget to develop standards for measuring matter (weight, volume, area, etc.) and energy (work, power, illumination, dry cells or batteries, etc.)

After you develop these standards, compare them with the standards developed and accepted by present day man.

ACTIVITY V

Discuss the problem involved in changing a standard such as the inch, foot, and yard system we use, to one more universally accepted such as the metric system--see Appendix.

THE COMPOSITION OF AIR

CONCEPT: Air is composed of molecules of gases and molecules of other particles and is in a constant state of agitation.

ACTIVITY:

Determine the Density of Air

Step 1. Using an old radio vacuum tube, the larger the better, pry or saw off the base, exposing the tip.

Step 2. Throw away the base. Weigh tube.

Step 3. Break the tube by directing a blowpipe flame at its tip. Heat causes the outside air to be able to push the softened glass inward and no material is lost.

Step 4. Weigh the tube again. Subtract the weights and get the difference.

Step 5. Fill the tube with water and measure its volume.

Step 6. Using the density formula ($D=\frac{W}{V}$), the density of the air, at the time of the experiment, is obtained.

*NOTE: An accurate balance should be used, as well as careful measurements of weight and volume.

CONCEPT: Air pushes in all directions.

ACTIVITY:

Step 1. Blow up a balloon.

Step 2. Point out that if air did not push in all directions, the balloon would be distended or sagging in the direction where there was no pressure.

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NEWTON'S 2ND LAW (f=mxa)

CONCEPT: Newton's second law can be stated in the following way: The rate at which the momentum of a body increases or decreases depends on the amount and direction of the force applied to the body.

TEACHER INFORMATION:

This second law of motion explains the direct relationship or inter-dependency between mass and force applied to the mass. A great force will cause a body to increase or decrease in speed more than a small force. A force on a body of small mass will cause it to increase or decrease in speed more than will the same force on a body of great mass. The following activities may help illustrate this law.

ACTIVITY I

1. Attach a rubber band to the front of a roller skate.

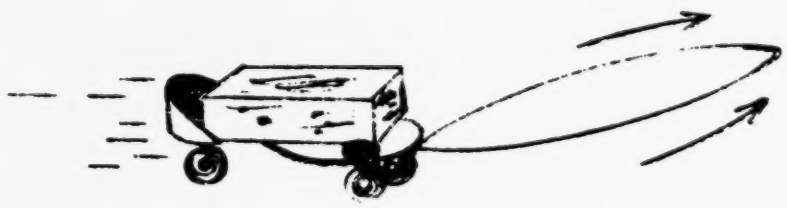
2. Place a brick on the skate and pull the rubber band to move the skate. (Figure 1.)

3. Note the stretch.

4. Add another brick to increase the mass.

5. Pull the rubber band to move the skate and note the difference in stretch.

(note: It can also be pointed out that once the mass is moving, it does not take as much force to keep it moving.)



ACTIVITY II

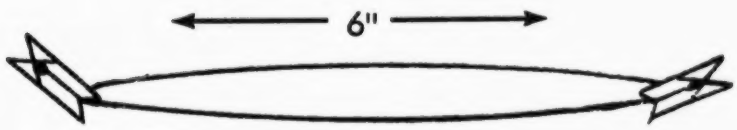
1. Attach a spring clothespin on either end of a light rubber band.

2. Stretch the pins apart to about 6" or so.

3. Release at the same time and note the position in which the pins come to rest. It should be roughly half way. (Figure 2).

4. Add another pin to one side, stretch to about 9", and release at the same instant.

5. See the position in which the pins now come to rest. (see Figure 3.)



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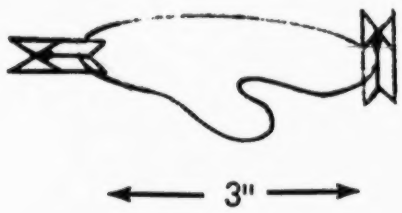
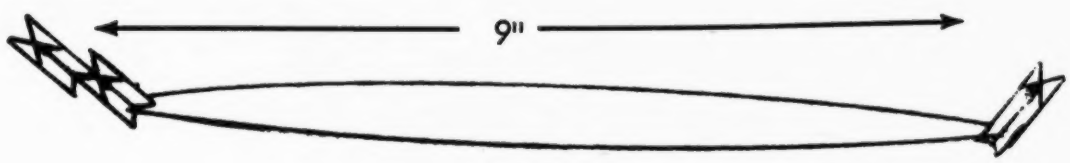
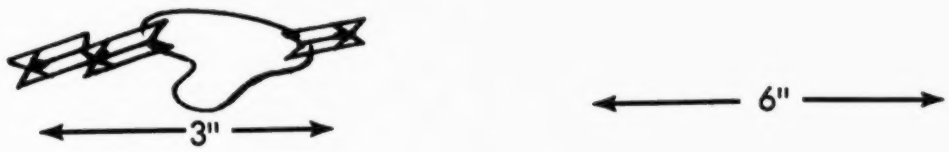




(Figure 3)



SATELLITE ORBITS

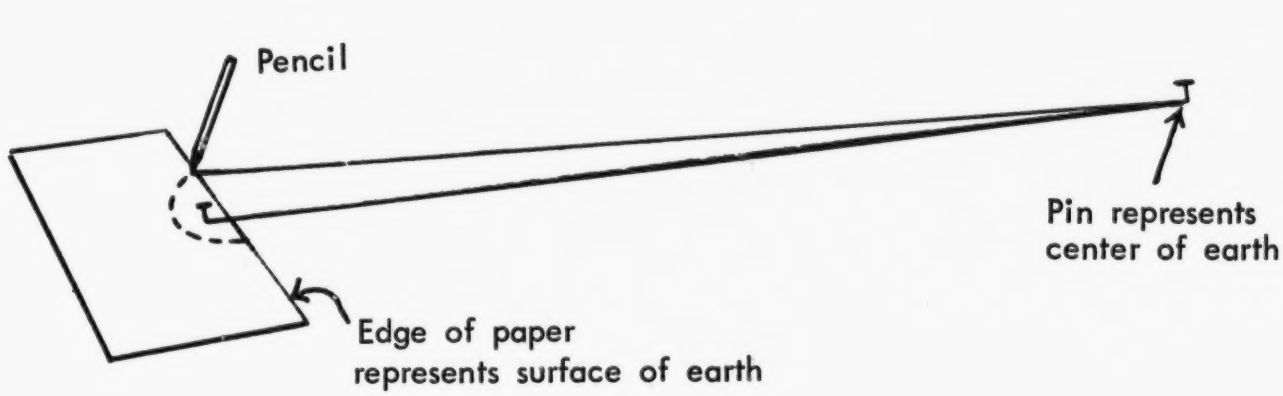
CONCEPT: According to J. Kepler, all satellite orbits are ellipses.

TEACHER INFORMATION:

Review the works of Kepler in the Encyclopedia. Any object thrown into the air will describe a small part of its total elliptical path around the center of the earth.

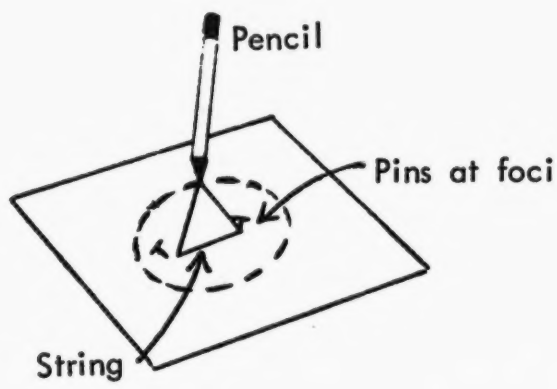
ACTIVITY I

To simulate the elliptical path in reference to the earth's center (figure 1) use the following experiment: The string should be 1" longer than the distance between the two pins (Foci). Place pins 20 feet apart.



(Figure 1)

ACTIVITY II Drawing an ellipse--complete orbital plane



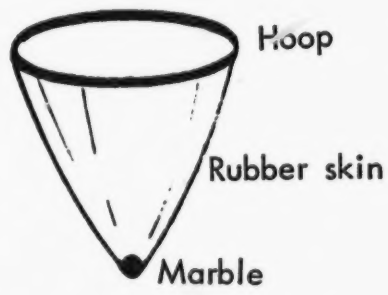
ACTIVITY III

To demonstrate the effects gravity has upon orbit shapes, use the following materials:

1. large 10¢ balloon
2. embroidery hoops or
3. oatmeal or coffee can
4. BBs and heavy marble
5. small rubber band

Step 1 - Cut the balloon in half and stretch it across hoops or cans.

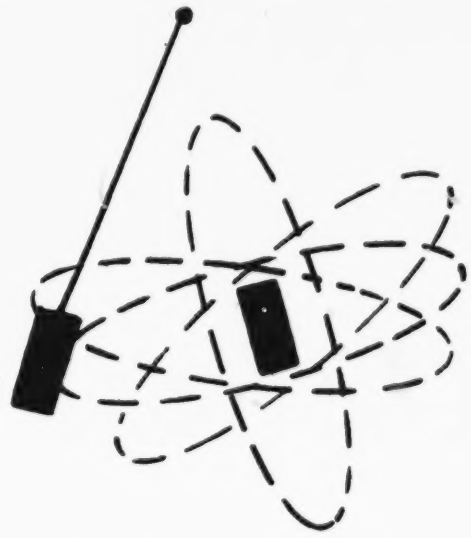
Step 2 - Wrap the marble in a balloon half and anchor it with a rubber band.



Step 3 - Pull down on the marble and stretch the rubber skin. Start a BB rolling down the sheet on the inside of the cone. It will be deflected similar to a comet by taking a hypabolic or parabolic path. Or it may be deflected to produce an elliptical path similar to a planet. If the path is elliptical, note the changes in the speed at perigee and apogee.

ACTIVITY IV

Attach a length of #10 sewing thread to either end of a small bar magnet and suspend the bar from the ceiling - on the floor or table top under the suspended magnet place another bar magnet with the unlike poles facing each other. Adjust the length of the string for best inaction between the magnets--fixed and swinging--and start the motion of the "satellite" by swinging the satellite magnet about one foot around the foci (fixed magnet). The eccentric circles described will illustrate motions of comets, planets, satellites, etc.



Would a piece of iron under a stationary magnet make the force field stronger? By having poles face each other, what happens to the figures described?

Activity under NEWTON

FALLING BODIES

The fact that the distance a body falls is proportional to the square of the time may be demonstrated by this very simple apparatus:

Attach to a piece of string 5 wooden blocks as shown in the sketch.

When the upper end is released, the blocks strike the floor at 1/4 second intervals. The fact that the impacts are equally spaced is apparent from the sounds.

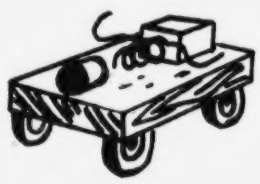
If the room is not high enough, one can hang the string out the window.

ACTION AND REACTION

A. 1. Sit on a bar stool or piano stool with your feet off the floor.

2. Throw a pillow in one direction--you will rotate on the stool in the opposite direction.
The heavier the object thrown, the better the backward force you will experience.

B.



Materials:
1. toy truck
2. empty can
3. spring
4. board and block
5. matches
6. thread

1. Mark the position of the truck.

2. Compress the spring and tie it to the can with thread.

3. Rest the spring can system on the board and against the block.

4. Burn the string. The spring will shoot out the can.

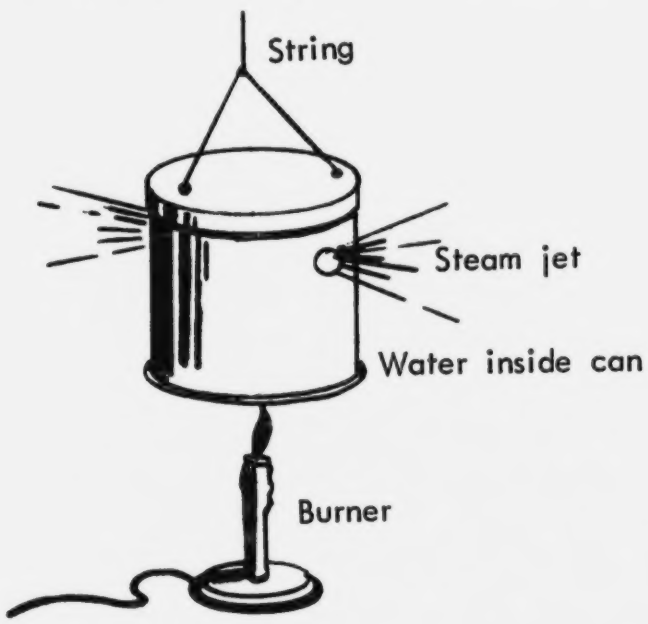
5. Note the recoil of the board.

C. A simple Herds engine

1. Punch holes on opposite sides of the can near the top.

2. Add about 1/2 inch of water to the can and cap tightly.

3. Suspend the can by a string. Heat the can with a burner or alcohol lamp.



METEOR DETECTORS

CONCEPT: Meteoric impacts with spacecraft can be measured.

TEACHER INFORMATION:

Satellites have been designed to record and measure meteoric impacts in space. Some of these sensors work on the measurement of positive and negative air pressure using aneroid barometers. The following activity shows this principal but in reversed air pressure--negative to positive.

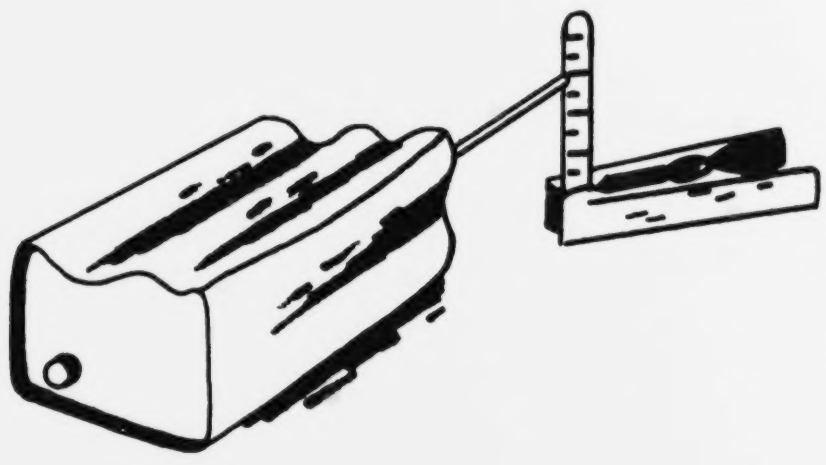
ACTIVITY:

Step 1.
Crush a one-gallon Ditto can. Boil a small quantity of water in the bottom, remove from the fire, and cap. As the water cools, the can will be crushed by outside air pressure. Do not remove the cap !

Step 2.
With some cellophane tape, attach a soda straw at one end. This now serves as a pointer for your aneroid barometer (the can). With changes in pressure, the straw will move, up with increased pressure and down with decreased pressure.

Step 3.
Make a marker by using a doctor's tongue depressor held upright by a spring-type clothes pin.

Step 4.
Using an ice pick to represent a meteor, puncture the can. Note the immediate change in the pointer.



REMOVAL OF CO_2 FROM A SPACECRAFT

CONCEPT: Carbon dioxide is removed from a spacecraft.

TEACHER INFORMATION:

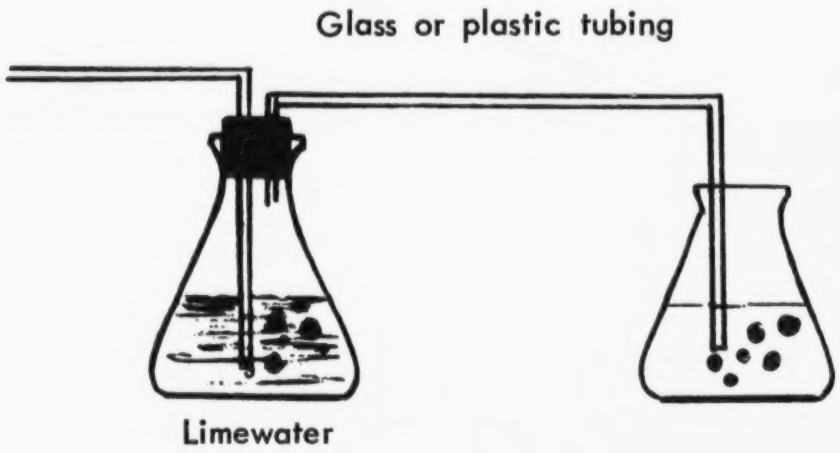
Since man must carry his environment into space with him, we have to keep this ecological system as nearly in balance as possible. Therefore, we have to provide means of removing certain gases that are introduced into this system through the natural biological actions of the human passengers.

ACTIVITY - Removal of Carbon Dioxide Gas

Carbon dioxide exhaled by the astronaut must be removed to prevent suffocation by the gradual build-up of this gas.

Step 1.
Bubble your breath through some fresh limewater. It will turn milky as the carbon dioxide gas reacts with the limewater. This is a test for carbon dioxide.

Step 2.
Bubble your breath through another sample of limewater, this time in a closed flask, as shown in the diagram. The tube from the flask should lead into another container of limewater. Compare the filtering effect of the first solution. More limewater filters can be added, making the effect more obvious.



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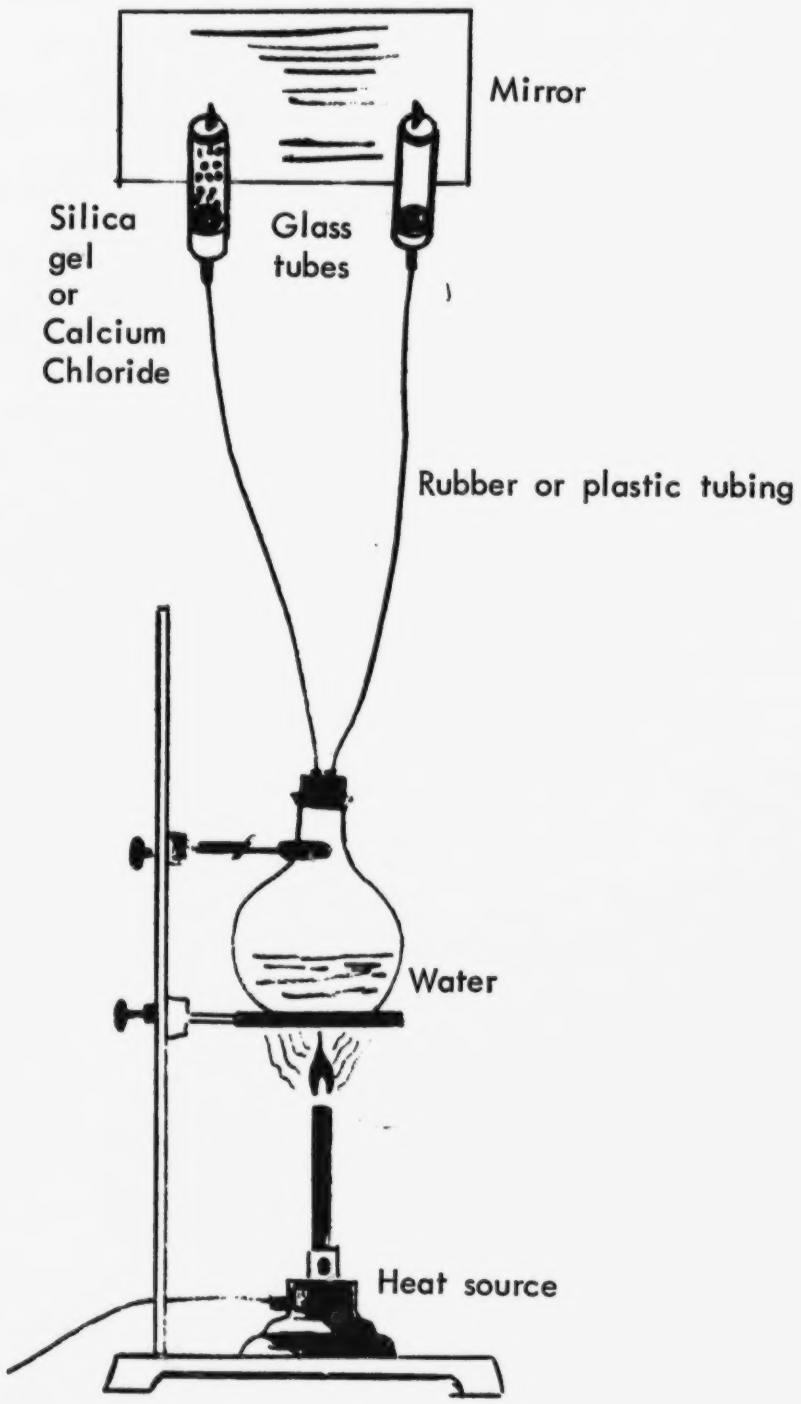
Demonstration showing one method of removing water vapor from the air.

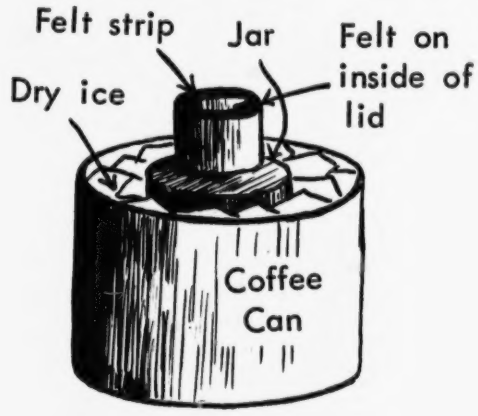


RADIOACTIVE PARTICLES

CONCEPT: Most satellites and manned space capsules contain instruments to detect and measure atomic (nuclear) radiation and cosmic rays. You can actually see these radio-active particles with a CLOUD CHAMBER.

ACTIVITY

Step 1.
Cement the weatherstrip around the inside of the jar at the bottom.



Step 2.
Cement a black velvet strip around the inside of the mouth of the jar, and a velvet disk to the underside of the jar cap.

Step 3.
Pour in enough alcohol to saturate the felt strip about 1/8 inch in the bottom of the jar.

Step 4.
Close the cover, invert the jar and rest it on a slab of dry ice (about 1/2 to 1 pound) which is imbedded in cotton batting in a coffee can.

Step 5.
Shine a beam from a light source such as a slide projector through the jar, and look in toward the black background. You should be able to see trails of cosmic rays.

The room need not be totally darkened. Use only rubber cement and allow plenty of time for it to dry. The container should be air-tight if possible to cut down on the possibility of convection currents.

The "cloud" looks somewhat like the movement of dust particles seen in a dark room when the sun is streaming in. The trails (either from natural cosmic particles or by placing a speck of "radium" from a luminous clock) look like small pieces of white thread dropped into the cloud. Most of the particles will be alpha from this speck of clock dial. A watch with a luminous dial can be held near the jar, also.

If the cloud suddenly stops, re-wet the strip with alcohol and the chamber will renew its activity.

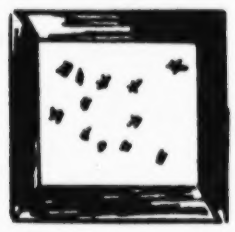
PROJECT CONSTELLATIONS

CONCEPT: Our night sky has groups of stars that form constellations. These are such outstanding features of our sky that we can use these to locate ourselves in space in relationship to the earth.

ACTIVITY I

Step 1.
Punch holes with a pin into 35mm transparencies (blackened, over-exposed, without pictures) to form pictures of the constellations.

Step 2.
Project on a 2 x 2 slide projector.

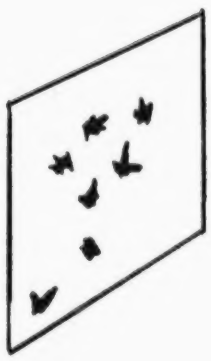


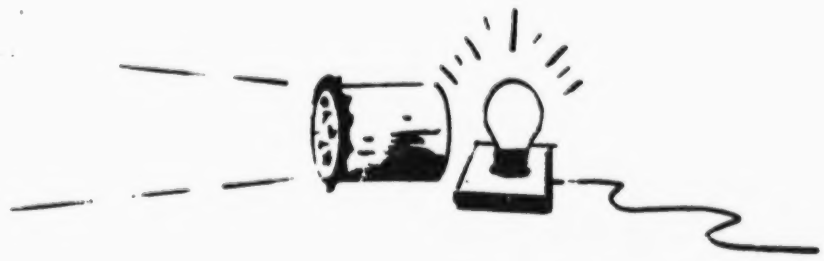
ACTIVITY II

Step 1.
Tape black construction paper on the end of an orange juice can in which the bottom has also been removed.

Step 2.
Punch holes to represent the stars in their constellations.

Step 3.
Shine a flashlight or other light source through the can.





EARTH'S MOTIONS

CONCEPT: We can see the result of the earth's rotation by taking time exposure photographs of our night sky. Night sky photographs also enable us to look into the physical make-up of stars and other heavenly bodies.

ACTIVITY

Step 1.
Pictures should be taken on a clear night where there are few disturbing extraneous lights (such as street lamps, etc.). The moon should not be visible. Load the camera with "fast" film.

Step 2.
Set the camera on "time."

Step 3.
Place the camera on a tripod, table, or some other secure stand.

Step 4.
Make a series of time exposures, from a few seconds to 10 or 15 minutes or longer.

To get a star trail photo, face the camera toward the pole star, "Polaris," and take prolonged shots. You will note the circling pattern of the stars as the earth rotates and "pans" your stationary camera across the sky.

Consult your local newspaper, in the Weather Information Section, for the times and locations of the passing of the Echo satellites. These bright satellites are photographed the same way in making star trail photos.

If you have an adjustable camera, set it at infinity and to the largest lens opening.

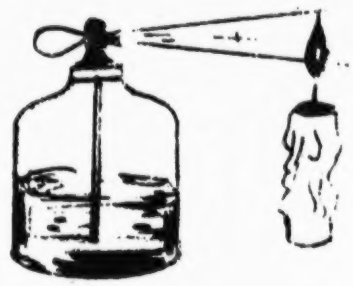
AFFECT OF STATE OF SUBDIVISION ON COMBUSTION

CONCEPT: Propellants in modern liquid rockets are mixed in the combustion chamber in the form of a spray.

ACTIVITY I

Step 1.
Place some alcohol into an empty bottle with a spray attachment (Such as Windex)

Step 2.
Spray the alcohol onto the flame of a candle.



ACTIVITY II

Step 1.
Place the following pieces of material in a burner flame: block of wood, wood shavings, sawdust.

Step 2.
Sprinkle lycopodium powder (obtainable at many drugstores or supply houses) onto the flame.

ROCKET PROPULSION

CONCEPT: The mass of the particles expelled from the nozzle of the rocket multiplied by the velocity at which they are expelled is equal to the mass of the rocket multiplied by the velocity at which it moves.

TEACHER INFORMATION:

This concept can be illustrated perhaps easier than explained. The following activity may help. MV = MV (action reaction--Newton's Law of Motion)

ACTIVITY

Step 1.
Obtain a toy water rocket (about $2.98) which comes equipped with a hand pump and a funnel for adding water.

Step 2.
Pump the empty rocket about 20 times and release. It will go about five feet as the air particles rush out of the nozzle.

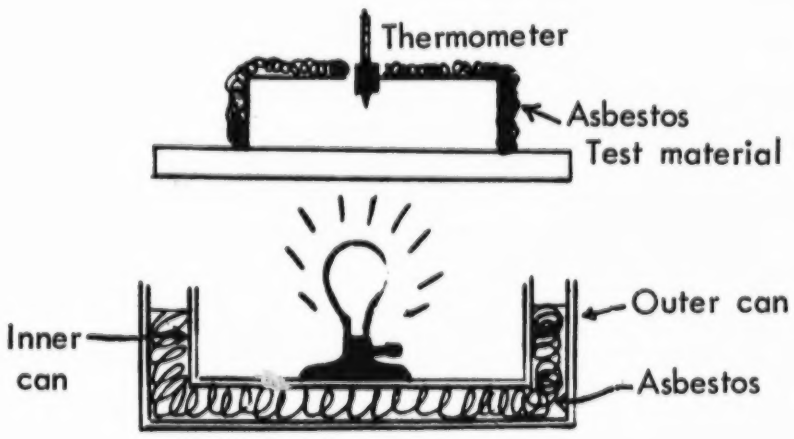
Step 3.
Add 20 ml. of water and pump the same number of times. Release. Now it goes quite a distance due to the additional mass of the particles of water fushing out of the nozzle.

INSULATING ABILITY OF VARIOUS MATERIALS

CONCEPT: One of the biggest problems with the use of various cryogenic (extremely cold liquified gases) fuels and oxidizers is the proper storage and insulation.

ACTIVITY

The apparatus below can be used for more accurate evaluation of various insuiators. Materials that might be tried may include various types of building materials, reflective materials, metals, and the like.



PURITY OF FUELS

CONCEPT: Propellants for rockets must be extremely pure. Even small quantities of impurities in a rocket fuel can cause improper oxidation and serious problems resulting in reduced thrust.

ACTIVITY

You can examine a common fuel (gasoline) for a common impurity (water) by this test.

Step 1.
Obtain some copper sulfate cyrstals from the drugstore.

Step 2.
Place an ounce or so in a pyrex dish in the oven at about 490° F. Allow the chemical to remain until it turns a pale gray color. All the water is now removed and what you now have is known as anhydrous copper sulfate. Put the powder in a bottle when it is cooled and cap tightly.

Step 3.
To test for water in the gasoline samples you have secured, place a little of the powder in your sample bottles and shake. If the gasoline contains water, the powder will return to its original blue color. Otherwise the copper sulfate will remain gray.

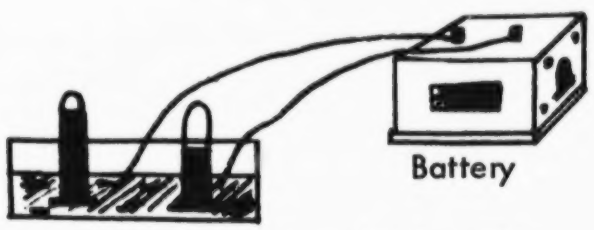
OXYGEN AND HYDROGEN - ROCKET PROPELLANTS

CONCEPT: Both oxygen and hydrogen are now used as rocket propellants. Oxygen has been used for some time as the oxidizer (to support burning) and just recently hydrogen has been successfully used as a rocket fuel.

ACTIVITY I

Some of the basic properties which make oxygen and hydrogen suitable for rocket propellants can be studied through the following demonstration:

Preparation: Method I - Electrolysis of Water



Water with a little sulfuric acid

1. Carbon poles from ordinary flashlight cells are connected by wires to a 6-volt battery.

2. A large battery jar or similar wide-mouth jar is 1/2 filled with water. A little Sulfuric Acid is added.

3. Two test tubes are filled to the top with water and inverted over the carbon poles in the jar. (Hold your thumbs over the tops of the test tube until they are below the surface of the liquid in the jar).

4. Hydrogen will bubble into one tube displacing the water. Oxygen will bubble into the other. There will be twice as much hydrogen as oxygen.

Preparation: Method II - Reactions with chemicals to produce larger quantities of gases.

1. To make oxygen, mix hydrogen peroxide (from the drugstore) and manganese dioxide* (the black powder from an old flashlight cell). Oxygen evolves. These can be mixed without any danger in an open jar or glass.

*Common laundry bleach such as Clorox can be used to replace the manganese dioxide.

Demonstrations with Oxygen

1. Place a glowing splint of wood into the oxygen. It will burst into flames.

2. Heat a ball of steel wool to glowing with a burner. Then thrust it into the oxygen. Note that oxygen supports combustion and increases the rate of oxidation.

Demonstrations with Hydrogen

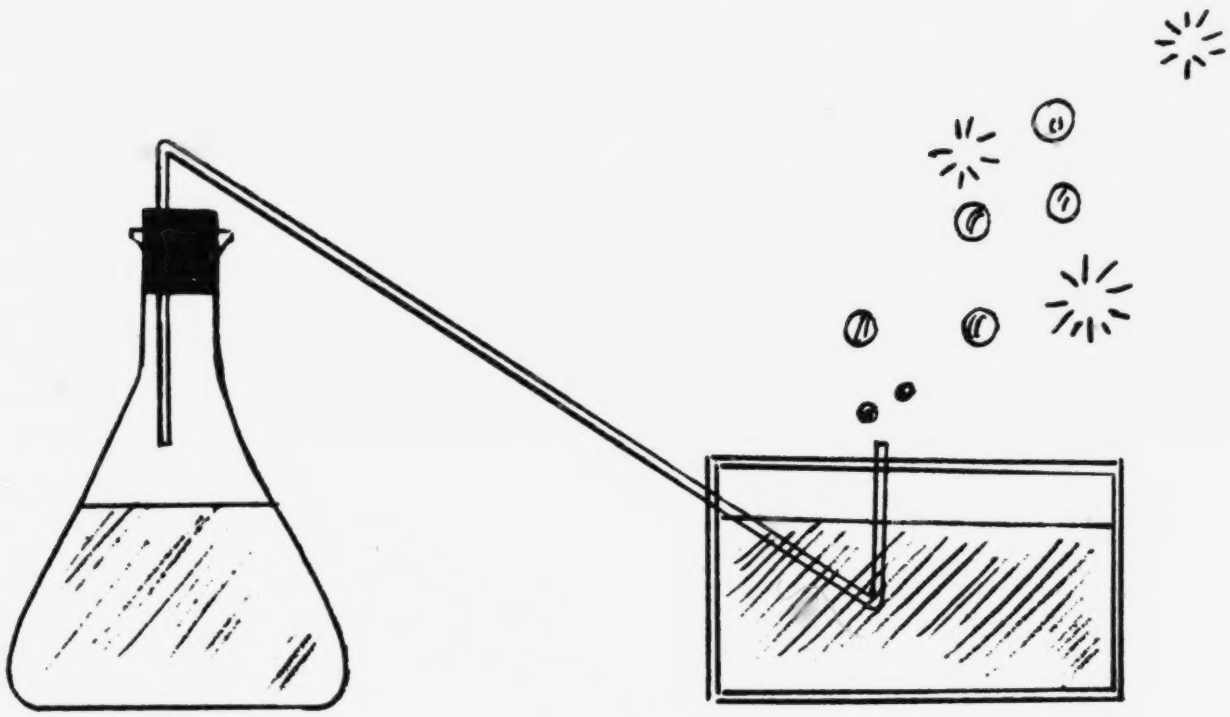
1. Generate a small amount of hydrogen by placing a small amount of zinc in a flask and pour in enough hydrochloric (muratic) acid to cover the metal. Insert a one-hole rubber stopper with an outlet tube into the flask (see diagram on page 3).

Allow time for the air to escape from the flask and then place the open end of the delivery tube into a dish of "bubble solution"* (10¢ store variety). The bubbles formed by the hydrogen gas will float upward. Ignite the bubbles! (figure 1)

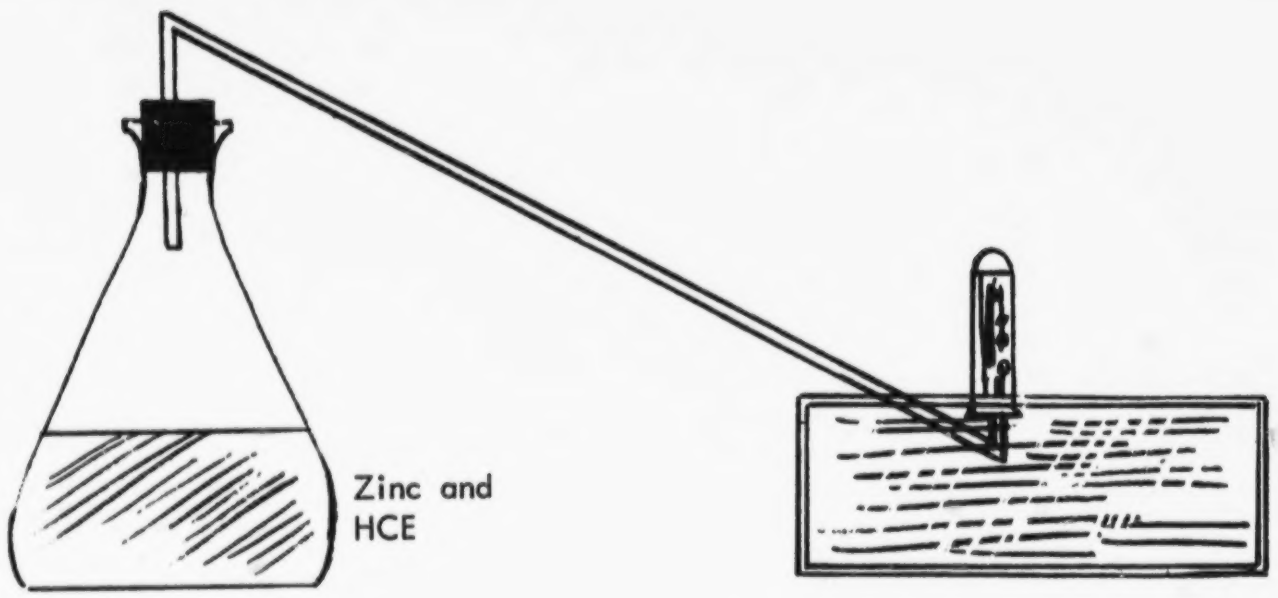
2. Collect hydrogen in a test tube and ignite it with a kitchen match (figure 2)

* A mixture of glycerine, powdered soap, and water is a good substitute for "bubble solution."

(Figure 1)



(Figure 2)



EFFECTS ON LOW TEMPERATURES

Many U. S. rockets use liquid oxygen (LOX) as a rocket propellant oxidizer. Some of our latest rockets use liquid fuels (liquid hydrogen) colder than LOX.

Some spacecraft use liquid nitrogen to spin stabilize the craft as altitude control jets. The gas is spurted through openings to act as jets.

In outer space the craft is exposed to extreme temperatures--extreme cold on the dark side and extreme heat on the sunlight side.

Changes in physical properties of various materials occur at low cryogenic temperatures.

Method i - Using liquid nitrogen

ACTIVITY I

Step 1.
Obtain a large thermos bottle of liquid nitrogen.

Step 2.
Immerse various objects into the liquefied gas (such as rubber tubing (small diameter), a flower, small hollow rubber ball, an egg).

Step 3.
After a few seconds, pull the object out and tap it on a table or crush it to show hardness and fragility.

ACTIVITY II

Step 1.
Repeat the above experiment using a lead sheathing from a telephone cable (approximately 9 1/2" x 2" in diameter is fine).

Step 2.
Before immersion in the nitrogen, strike the suspended sheath (from wire through holes drilled at the top) with a hard rubber hammer (toy store variety is good)

Step 3.
Sink the lead sheath into the LN_2 until the fast boiling ceases. Take it out and strike it again.

ACTIVITY III

Step 1.
Obtain a 35mm film can and punch two holes with a nail or ice pick, each on opposite sides, about 3/4 from the bottom. After punching, give each hole a slight twist as shown in the sketch (top view).

Step 2.
Support the can by strings.

Step 3.
Pour some liquid nitrogen into the can and cap. Note that the LN_2 will vaporize producing a gas which will turn the can.

Method II - Using non-cryogenic liquid to achieve extreme cold

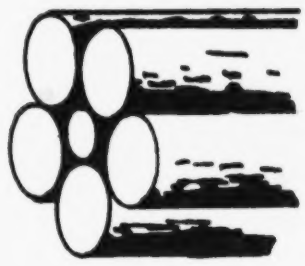
The experiments pointed out above may be performed using a mixture of dry ice and acetone (alcohol may be substituted for the acetone if this is not available).

CLUSTERING AND STAGING

CONCEPT: Rocket engines can be combined in clusters or groups. By doing this, greater total thrust can be achieved than by building one huge rocket engine.

TEACHER INFORMATION:

Clustering



Rockets can also be stacked (staged) on top of one another. By doing this, dead weight can be eliminated from the rocket as it ascends by releasing the stage that has burned all of its fuel, and allowing it to fall back into the atmosphere. Thus the remaining stages do not have to drag the dead weight of the burned out stage along with them. This enables the remaining stages to increase in velocity and climb in altitude.

Using these advancements in our technology, man is able to send various sizes and weights out into space either to be placed in orbit around our earth or sent out into deep space.

We can expect some dramatically new forms and types of rockets in the future. New fuels such as nuclear power, ion power, and power from plasma engines are some examples.

ACTIVITY I - Staging

Given: one truck, one jeep, and one motorcycle, each with a range of 200 miles. Gas tanks are full and sealed. How could you get across a desert to the nearest oasis 600 miles away?

ACTIVITY II

Stack three bricks one on top of the other. Lift all three from the floor. Drop the lower one. Is as much energy required to continue lifting the remaining two bricks? Continue to raise the bricks, dropping the second brick. What is observed?

ATTITUDE CONTROL

CONCEPT: Many spacecraft use small gas jets to control the craft's attitude and stability.

TEACHER INFORMATION:

To illustrate how a small gas jet can control or cause an object to move in a certain direction, the following demonstrations can be performed:

ACTIVITY

Step 1.
Punch a hole through the cap of an unopened bottle of any carbonated soft drink.

Step 2.
Hold your finger tightly over the hole and shake the bottle vigorously.

Step 3.
Release the bottle on a smooth surface. The carbon dioxide gas forces the drink out of the hole causing the bottle to move. (If the bottle is suspended from a string, it is more effective).

CAUTION: Since the liquid spews from the bottle several feet, the demonstration should take place outdoors with the observers at some distance. The student performing the demonstration should probably be wearing rainwear.

COLOR OF SKY

CONCEPT: Particles suspended in the atmosphere cause light scattering, creating the colors we observe in the sky.

TEACHER INFORMATION

Red light has a wavelength of $28/10^6$ inches and blue light is $16/10^6$ inches. Particles in the air are slightly larger than the wavelength of light and thus cause red scattering (at dusk and sunrise when sunlight passes through more air). Normally, atmospheric gases are smaller than the wavelength of light causing the blue scattering as seen as skylight.

ACTIVITY I

Outer space looks black, but to see why the sky looks blue (or red at sunset) to us earthlings, try the following:

Step 1.
Demonstration should be done in a dark room.

Step 2.
Add milk to a jar of water, a drop at a time. Stir the mixture constantly. Shine a strong light through the jar.

Step 3.
Look through the side of the glass. It looks blue.

Step 4.
Look into the light. It looks reddish-yellow. The long red waves of light move through the emulsion with little scattering. The blue and violet waves scatter quite easily, showing up well from the side view: the view which lighted only by scattered light.

NOTE: A variation which works particularly well is to all vinegar to a concentrated "hypo" solution. (Hypo is acid fixer used by photographers.) The chemical is sodium thiosulfate and is obtained inexpensively at the camera shop or drugstore. Use the light as before.

Another variation is to use a soap solution (not detergent) instead of milk.

ARTIFICIAL GRAVITY FOR SPACE STATIONS

CONCEPT: Artificial gravity for space stations can be produced by rotating the station on its axis.

TEACHER INFORMATION:

For prolonged living on a space station, a "gravity" will have to be produced. To produce this artificial gravity, the space stations will be rotated on a central axis. To show how the interaction of motion with inertia results in this "gravity":

ACTIVITY I

Step 1.
Cut a strip of paper one inch wide and slightly longer than the circumference of a phonograph turntable.

Step 2.
Attach the strip around the rim with scotch tape.

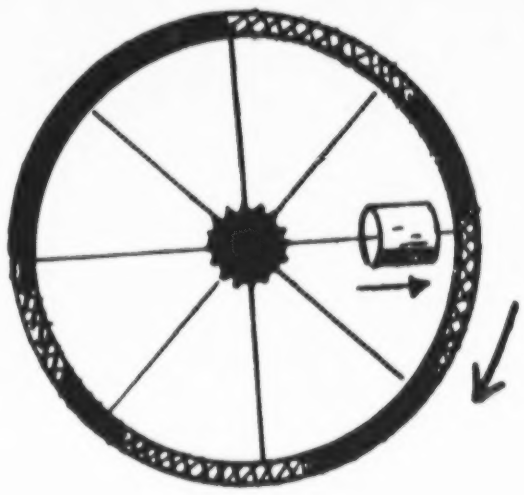
Step 3.
Start the motor. Use 78 rpm and drop a marble close to the water center of the disc. Note that the marble moves "down" toward the edge of the rotating disc.

ACTIVITY II

Slip a section of mailing tube over a spoke of a bicycle wheel. Notice the tube stays "down" near the rim when the wheel is turned. (figure I)

ACTIVITY III

Partially fill a bucket with water. Twirl the bucket over your head. The ~~water~~ stays "down" in the bottom of the bucket.



LUNAR PROBES

CONCEPT: Instruments are being sent to the moon that will give us a greater understanding of the structure of the moon.

TEACHER INFORMATION:

The NASA Surveyor spacecraft will contain a variety of experiments to investigate the moon's surface.

One of these experiments will test the hardness of the moon's crust.

ACTIVITY I

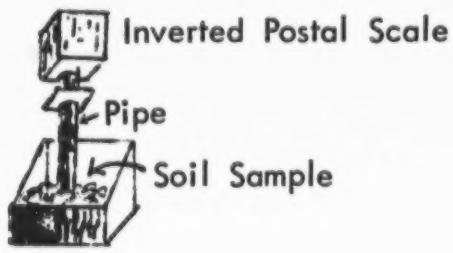
A simple way of showing how we can compare different degrees of hardness is to push a soda straw through:

1. cotton
2. marshmallows
3. rice
4. coarse gravel
5. dirt
6. small rocks
7. white potato

Try again using a plastic strip, a wooden strip, and a metal bar.

ACTIVITY II

Strain gauges will be attached to the hardness probe on the Surveyor. A way to get some quantative measurements on the hardness of the "surfaces" is to compare the amount of weight required to push a piece of copper tubing or pipe into the soils.



ACTIVITY III - Bounce Method

Step 1.
Get a glass or plastic tube one foot long and 1" in diameter and marbles or steel balls small enough to fall through the tube--and a one-foot ruler.

Step 2.
Stand the tube on the surface to be tested.

Step 3.
Drop the marble down the tube on to the surface.

Step 4.
Measure the height of the bounce. The ratio between the rebound and the original drop can be labeled as index of surface hardness.

PRODUCING A NEGATIVE PRESSURE

ACTIVITY I

Materials:

1. an empty duplicator fluid can
2. rubber tubing and stopper

Step 1.
Place the can on a window ledge and allow the free end of the hose to dangle out of the window.

Step 2.
The can will slowly collapse.

Step 3.
The 6-foot column of water produces a negative pressure of 6/34 x 15 lb/sq. in. within the can (or 2 1/2 lb./sq. in.). The difference of pressure causes the can to be compressed by outside air pressure.

ACTIVITY II

The traditional method of producing a negative pressure (other than using a vacuum pump) inside a container such as a ditto can is to place a little watter in the can and boil. After the water is vigorously boiling, remove the can from the flame and cap it quickly. As the steam that was produced by the boiling water condenses, the internal air pressure causes the can to be compressed. (Note: Do not uncap the can. Allow it to cool completely and save it for a future experiment.)

STRESSES ON METALS

CONCEPT: Stresses and strains in structures cen be observed by polarizing the light that is reflected from the strain point.

ACTIVITY - Stresses made visible

Step 1.
Fasten two clamp-spring type clothespins, one behind the other, to a base about 2" apart.

Step 2.
Clip two polaroid lenses in the supports. The lenses can be obtained from a pair of polaroid sunglasses.

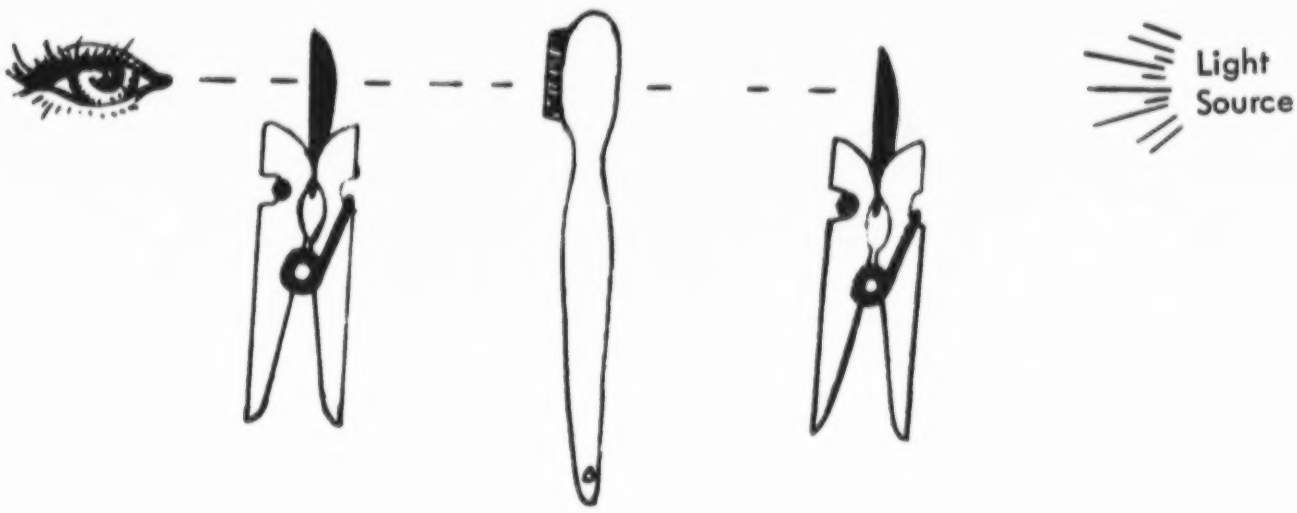
Step 3.
Rotate one lens until the maximum smount of light coming through is excluded. Darken the room.

Step 4.
Place a lighted flashlight or bulb about a foot behind one of the lenses, on the same level.

Step 5.
Hold a plastic specimen, such as a toothbrush or comb, between the two polaroid lenses and look at the specimen from the side opposite the light.

Step 6.
Bend the plastic and notice the colorful fringes, or stress patterns.

Step 7.
Cut a notch in the center of the plastic and repeat the experiment. See how the stress lines pile up around the notch, indicating that the stress is the highest at that point.



CROWING CRYSTALS

CONCEPT: There are several areas in space research and applications in which crystals play a most vital role.

TEACHER INFORMATION

Crystals are used to keep the spacecrafts' radios on the correct frequencies. Special super pure cyrstals of sillicon are carefully sliced and treated to form solar cells. Crystals of certain elements are used in making semi-conductors.

ACTIVITY - You can grow cyrstals of sugar called rock candy very easily.

Step 1.
Heat some water and add as much sugar as will dissolve.

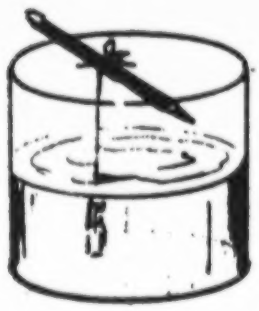
Step 2.
Pour the solution into a glass.

Step 3.
Tie a weight (such as a small nut) on one end of a string and a pencil on the other.

Step 4.
Suspend the spring in the middle of the glass as shown.

Step 5.
Allow the solution to remain undisturbed for some time.

The sugar will crystalize on the string. This is commonly called rock candy and illustrates crystal formation.



ACCURACY IN MEASUREMENT

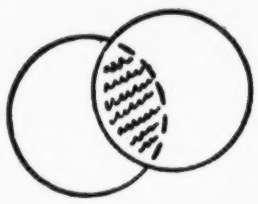
CONCEPT: Measurements in the space age are no longer a matter of getting accuracies Of 1/1000 of an inch. Bearings and other parts must fit with such accuracy that it is almost beyond belief.

Several methods of checking for these necessary accuracies have been devised.

ACTIVITY I - Newton's Rings - for determining the smoothness of a surface.

Place two wet glass slides together and press them together. Allow the slides to dry. Irregular colored rings will be seen when the slides are viewed under white light. The greater the distortion of the bands the greater the irregularity of the smooth surface of the glass.

ACTIVITY II - Moire Pattern - used in determining the angles at which two objects are placed to each other.



Stretch transparent ribbed fabric across two embroidery hoops. When the hoops are rotated, the patterns resemble the moire pattern.

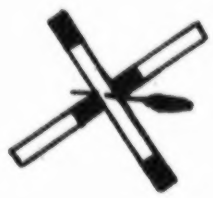
MOMENT OF INERTIA - ANGULAR MOMENTUM

CONCEPT: If the two astronauts that are sitting in an orbiting capsule move apart or closer together, the stabilization of the space craft will be affected.

ACTIVITY

To convey the concept of moment of inertia, prepare two aluminum tubes 3' long and 1 1/4" in diameter so that one tube is internally loaded in the middle and the other is internally loaded at the ends. Both tubes weigh the same, but if held in the center and rotated back and forth, the difference of loading becomes obvious.

By drilling holes in the center, an ice-pick can be placed through both tubes and will act as a short shaft having a handle. Now the tubes are rotated together and again the affect of placement of the load is obvious.



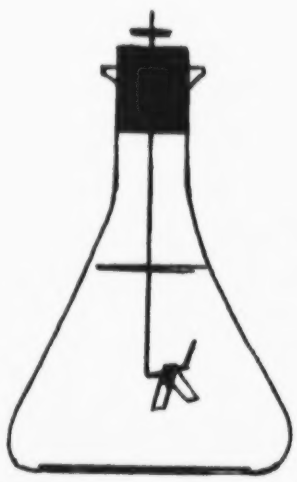
ENERGY PARTICLES IN SPACE

CONCEPT: Some of the energy particles moving through space have an electrical charge.

TEACHER INFORMATION:

Instruments have been designed to detect and measure the intensity of energy particles striking the surface of a spacecraft. These measurements are sent to ground receiving stations by telemetry signals.

DETECTION OF RADIATION



ACTIVITY

Step 1. Solder a penny to a piece of copper wire, then push the wire through a cork.

Step 2. Make a right-angle bend in the wire about 1/2" from the lower end.

Step 3. Cut a string of foil (from gum wrapper) about 1/4" wide by 2" long and hang it at its center over the bend portion of the wire. A drop of fingernail polish will stick it fast to the wire.

Step 4.
Place the whole assembly into a wide mouth bottle to protect it.

Step 5.
To charge the electroscope, rub a hard-rubber comb (ACE brand) over wool pants or a coat. Bring the comb near the electroscope and touch the penny with the comb. The leaves of the electroscope are now charged negatively.

A positive charge can be produced by rubbing a class or plastic rod with a polyethylene bag.

Step 6.
After charging the electroscope, bring a radioactive source near it. This source may be a luminous watch dial.

Step 7.
Note that the electroscope will discharge and the aluminum leaves will collapse.

CHANGES IN TEMPERATURE

CONCEPT: An object in space experiences constant changes of temperature.

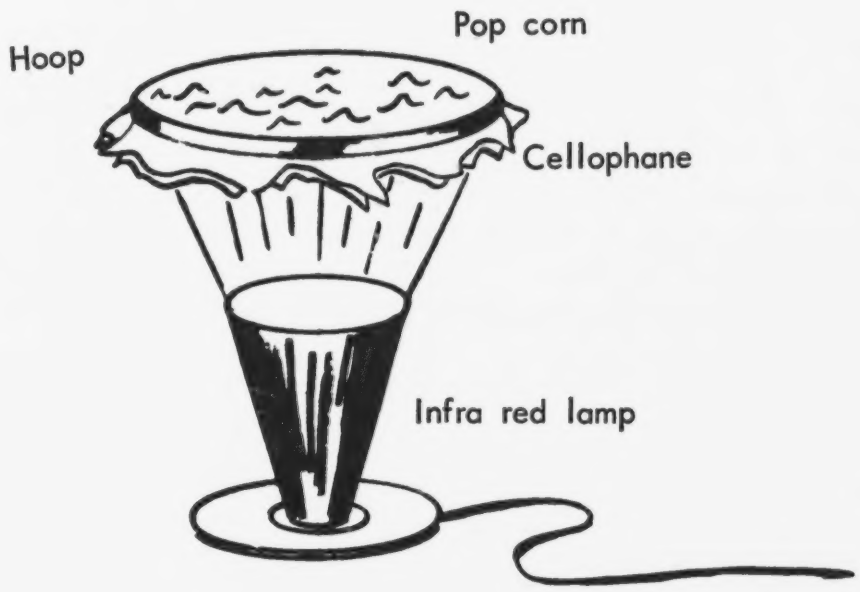
TEACHER INFORMATION:

As it rotates, the sunlight side of an object in orbit is extremely hot and the part of the side away from the sun is extremely cold.

Materials must be resistant to such changes and are constantly being tested and selected.

ACTIVITY

Light energy becomes thermal energy after it is absorbed by an object. This can be demonstrated by sandwiching pop corn between layers of cellophane (try different forms of plastic wrap found in the kitchen) held in an embroidery hoop. Hold this over an infra red lamp. In a minute or so the pop corn will pop but the cellophane is still cool.



HIGH SPEED ENERGY PARTICLES

CONCEPT: High speed energy particles are zipping through space at all times.

TEACHER INFORMATION:

Some high speed radioactive particles are coming into our atmosphere at all times. These energy particles are too small to be seen by the unaided eye, but methods have been developed to detect and identify them.

DETECTION OF COSMIC RAYS

ACTIVITY I - Diffusion cloud chamber

ACTIVITY II - Gieger Counter

ACTIVITY III - Photographic Emulsions to Detect Cosmic Rays

Step 1.
Obtain a package of Kodak Nuclear Emulsion film from Eastman Kodak Company, Rochester, N. Y. (purchased from their sales department).

Step 2.
Leave a sheet of film in a waterproof, light proof, container on the rood of a tall building for a month.

Step 3.
Develop the film according to the directions in the package. Dry.

Step 4.
Examine under a microscope for a "star" or "burst" where an atom has disintegrated by being struck by a cosmic particle.

In actual practice, scientists usually stash the special films of thick light-sensitive material in layers and carry them to high altitudes in balloons.

BUILDING A PERISCOPE

CONCEPT: Periscopes are used by scientists in rocket launching.

TEACHER INFORMATION:

During a rocket launch many scientists and technicians observe the firing in a nearby block-house through a periscope. The Mercury Spacecraft contained a periscope for the astronaut's use. A simple periscope can be constructed as shown below:

BENDING LIGHT AROUND CORNERS

CONCEPT: It is necessary at times to bend light around internal structures of the spacecraft to illustrate certain critical areas.

Materials:

1. Jar with a screw cap
2. black construction paper
3. flashlight

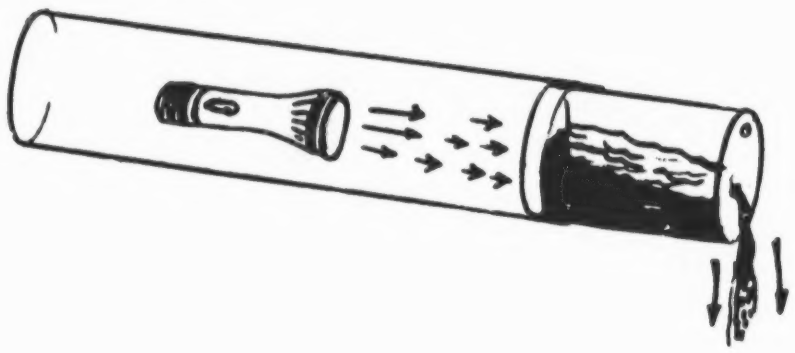
ACTIVITY

Step 1.
Punch two holes in the screw cap of a jar of water (one near rim and the other near the middle).

Step 2.
Wrap the paper, which is twice as wide as the jar is tall, around the jar past the bottom, as shown.

Step 3.
Stand near the sink, place flashlight against the bottom of the jar, inside the wrapping.

Step 4.
Tip the jar and light with the edge hole at the top. The water will run out the middle hole in a little stream.



SPACECRAFT TEMPERATURE CONTROL

CONCEPT: Certain materials absorb and reflect radiation at different rates. This knowledge can be used in the partial control of temperature aboard a spacecraft.

ACTIVITY

You can get firsthand knowledge of this technique by:

1. Place several thermometers under different materials of different colors and leave them exposed in the sunshine. Note the differences in temperatures.

2. Paint one tin can dull black and another silver (aluminum paint). Place a piece of cellulose sponge in the bottom of each and add identical thermometers to each can (the padding is to protect the thermometer). Place these cans eqyidistant from a heat lamp, hot iron, or open light bulb. Note the difference in temperature.

NOTE: In outer space we can only dissipate heat through radiation.

CHANGES IN TEMPERATURE DUE TO STRESS

CONCEPT: Stresses and strains cause an interconversion of heat.

ACTIVITY

Step 1. Take a wide rubber band and bring it in contact with the slightly-moistened lips.

Step 2. Now stretch the band swiftly as far as it will go without breaking. Again bring the rubber against your lips. Note that its temperature has risen appreciably.

Step 3. Hold the band in this stretched position for about 30 seconds (the rubber will return to room temperature).

Step 4. Release the rubber suddenly to its original unstretched length and touch it to your lips immediately. Notice how cool it is now.

HEAT ENERGY FROM FATS

CONCEPT: Foods for the astronauts must be specially prepared so as to anticipate the amount of heat energy that will be liberated during the normal processes of assimilating digested food.

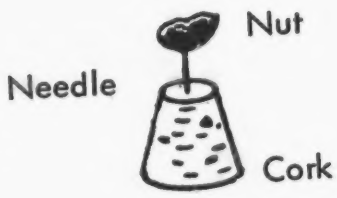
ACTIVITY I - To illustrate the large quantity of heat energy that is produced by food.

Step 1.
Take a large shelled butternut (or pecan, Brazil nut, etc.) and mount it as shown.

Step 2.
Cut a similar sized piece of soft wood and mount it in the same way.

Step 3.
Set fire to both and place under identical beakers containing equal amounts of water at the same temperature.

Step 4.
Record the highest temperature reached by each and the length of time each burned.



ACTIVITY II

Step 1.
Melt a small quantity of butter and pour it into a bottle cap.

Step 2.
Insert a cotton string (acts as a wick).

Step 3.
Place in the refrigerator until the butter solidifies.

Step 4.
Compare the "butter candle" you have made with one made in the same way using paraffin.

PHYSIOLOGICAL ASPECTS OF SPACE TRAVEL

CONCEPT: Physiological aspects of prolonged space travel have not been determined. Some areas that might come into consideration are nightlessness, long periods of sun light, reduced air pressure, constant tumble rate (controllable), cramped quarters, and hallucinations.

ACTIVITY - class project

Step 1.
Put a small caged animal on a record player turntable - three speed changer, if possible. Vary duration of different speeds. Observe animal during and after rotating - i.e., temperature respiration, etc. Time trained rats on a maze. Then time after spinning--observe possible disorientation.

Step 2.
Notice the effect of prolonged sleeplessness on animals--observe for signs of disorientation, irritability.

Step 3.
Notice the effect of prolonged lighting on small animals.

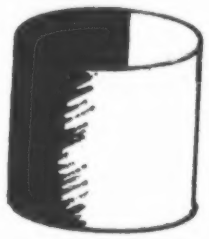
Step 4.
Put partially inflated balloon in a vacuum jar. Vary pressure.

SATELLITE COLORS

CONCEPT: Some colors absorb heat more readily than others.

TEACHER INFORMATION:

Satellites are painted or colored in certain patterns to absorb greater or lesser amounts of the solar energy to help protect instruments carried on the inside.



ACTIVITY I

Step 1.
Prepare the can as shown. Both top and bottom lids have been removed. The can should be cut through with a cold chisel on both sides and one half should be painted black.

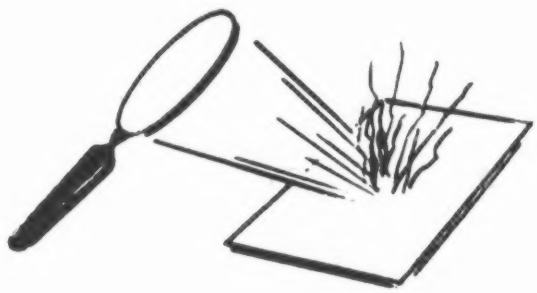
Step 2.
Place it over an open light bulb. Touch the sides. Which side feels hottest?

Step 3.
When cool, attach a match or tack with a drop of candle wax to each side. Repeat the above procedure. Which falls off first?

ACTIVITY II

Step 1.
Focus the sun's rays on a piece of newspaper where there is no printing or picture. See how long it takes before it catches fire.

Step 2.
Focus the sunlight this time on the black print.



OBSERVING SUN SPOTS

CONCEPT: Spasmodically irregular shaped dark blotches appear on the surface of the sun.

TEACHER INFORMATION:

Sun spots grow quite rapidly and then shrink and disappear. Some groups of spots may remain on the surface for days or weeks.

ACTIVITY I

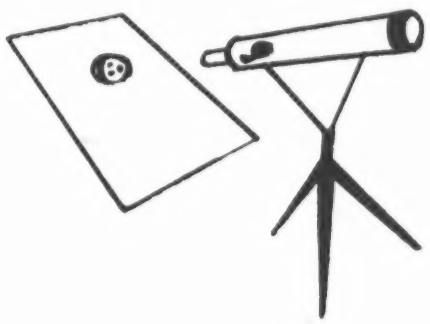
Step 1.
Under no circumstances should a person look directly at the sun. Any observer should use one of several protective techniques.

Step 2.
Cut the side from a cardboard box.

Step 3.
Mount a piece of white paper on the cardboard.

Step 4.
Aim a telescope or binoculars in the generai direction of the without looking through the telescope.

Step 5.
Hold the white "screen" at the rear of the telescope about 6" from the eyepiece and move them about until the image of the sun comes into focus.



NOTE: The farther from the eyepiece, the larger but dimmer the image.

ACTIVITY II

Step 1.
Trace the sun's image on the screen with a pencil.

Step 2.
Mark the position of the observed sunspots. Note their shape, size, and shadings.
On successive days, projecting to the same outline of the sun on the screen, mark the location of the sunspots. Use a different color each day.

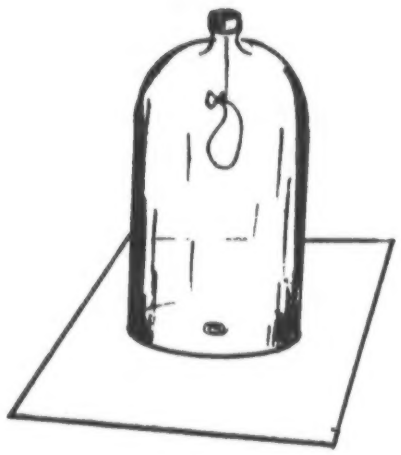
What do these activities tell you about the motions of the sun?

OUTERSPACE - A VACUUM

CONCEPT: Outer space is approaching a total vacuum.

TEACHER INFORMATION:

Under this vastly reduced air pressure, great care has to be exercised to prevent accidental explosions of spacecraft and experiments due to the differential pressures.



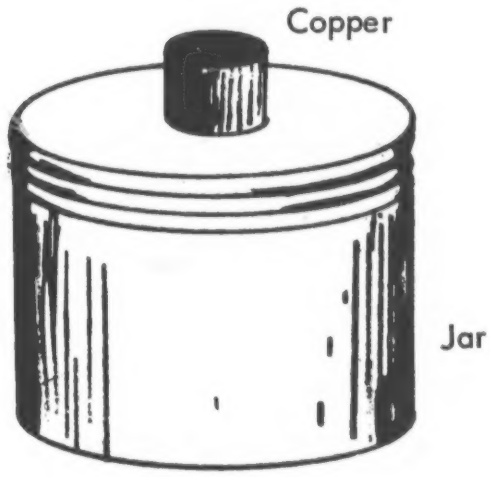
ACTIVITY

Step 1. Blow up a small round balloon to its maximum inflation point. Release a little of this air. Tie the inflated balloon close to its neck.

Step 2. Suspend the balloon in a bell jar.

Step 3. Remove the air from the jar with a vacuum pump. Note that the internal pressure of the balloon causes it to expand under a reduced outside pressure.

(If a bell jar is not available, a substitute can be made with a fruit jar. Drill a hole about 1/4" in diameter in the lid of the jar. Have a piece of copper (or tubing) pipe soldered in place as shown in the diagram. Allow the pipe to extend about 2 1/2" above the lid top. The lid should be capped tightly. The rubber tube to the vacuum pump should be attached to the extended copper pipe.



LIFE SUPPORT FOR MAN IN A SPACECRAFT

CONCEPT: Man is a result of his environment.

TEACHER INFORMATION:

When man goes into space, he must carry this same earth environment with him. Hence, the manned spacecraft and space suit are ecological systems that are patterned after earth's environment.

ACTIVITY - Closed systems

Step 1.
Hold a large, soft-glass test tube by its ends and rotate in a burner flame.

Step 2.
As the central area softens, remove it from the flame and pull it out quickly so that a narrow section is formed between the two larger ends. Do not pull it apart completely, but leave enough space to be able to add small plants and animals through the hold.

Step 3.
Being careful not to break the tube, set is aside to cool. Prepare several similar tubes.

Step 4.
After cooking, add aquarium water into each tube to about 1/2 the capacity of the lower section.

Step 5.
To some tubes add a snail and green aquarium plants. To others just add a snail.

Step 6.
Seal the tube by heating the narrow middle part of the tube and pulling it apart to form only a fine strand of glass (a microtube remains). The upper part will break away and may be discarded.

Step 7.
After cooling (and by this time all gases will have escaped, the center strand is easily cooled by touching it to the flame.

CAUTION: Be sure not to heat the liquid as you heated the tube.

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